

**UNITED STATES PATENT APPLICATION**

**FOR**

**METHOD OF OPERATING A SAFETY SYSTEM FOR AIRPORTS  
AND AIRFIELDS**

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# **METHOD OF OPERATING A SAFETY SYSTEM FOR AIRPORTS AND AIRFIELDS**

## PRIORITY CLAIM

5 This application is a divisional application of U.S. Patent Application Serial No. 09/727,276, filed on November 30, 2000, entitled, "SAFETY SYSTEM FOR AIRPORTS AND AIRFIELDS", Attorney Docket No. 112905/003.

10 **DESCRIPTION**

The present invention relates in general to a safety system for airports and airfields, and more particularly to a synthetic turf surface and accompanying sub-surface installed substantially adjacent to airport runways and taxiways and a method for installation of said surface and said sub-surface.

## **BACKGROUND OF THE INVENTION**

Airfields, including military airfields, small airfields and large commercial airports presently have grass surfaces adjacent to the airport runways and taxiways. These natural grass surfaces are difficult, time consuming and expensive to maintain and are not aesthetically pleasing. More importantly, the existing grass surfaces create potential safety problems for departing and arriving aircraft. The existing grass surfaces also create potential safety problems relating to the clean-up of hazardous waste spills and to the use of pesticides and herbicides necessary for proper upkeep of the grass.

One further problem with natural grass surfaces at airports or airfields is improper water drainage. In typical natural grass installations, the surface of the soil is approximately at the same height as the concrete (or other) surface of a runway or taxiway. The height 5 of the grass thus normally extends past the height of the runway or taxiway surface. Grass clippings, dust, dirt and debris blown across the runway or taxiway, catch the overextending lip of grass and collect adjacent thereto, creating a more extensive vertical barrier. The clippings, dust, dirt and debris trapped adjacent to the runway or 10 taxiway increase the potential of "foreign object damage" or "FOD" to airplanes and are therefore classified as "FODS." FODS are any foreign object that can damage a stationary or moving aircraft, specifically including a turbine engine.

The collected clippings, dust, dirt and debris along the edge of 15 the runway or taxiway also inhibit proper water drainage from runways or taxiways. This build-up also traps and pools rainwater that contacts the runway or taxiway and drains to their sides (i.e., down their grade). The water eventually drains into and through the build-up and often creates a three to four foot (30 to 40 cm) area of wet mud adjacent to 20 the runway. The grass in this area often dies, the mud dries and the top soil erodes so that new grass seed cannot effectively form a root system. Grass sod directly adjacent to a runway or taxiway can become loose, fly up and become a FOD, so that airports are effectively stuck with eroded soil in safety areas adjacent runways or 25 taxiways.

Commercial airports (and certain other airports) must include graded surfaces adjacent to airport runways and taxiways capable of handling a hundred year flood. A conventional grade for such surfaces is a drop in height of at least one quarter inch (.62 cm) for every foot

- 5 (30 cm) in a direction perpendicular to the runway, or approximately a two percent drop. Over time, the flow of water carrying dirt and debris away from the runway or taxiway erodes the grade, at least at certain points, in the natural grass surfaces adjacent to the runway or taxiway. Water tends to pool in such areas of the natural grass where the grade
- 10 is eroded. The pooled water also kills the grass and creates muddy areas where little grows. The muddy areas are aesthetically displeasing and conventional vehicles such as sanitation trucks, maintenance trucks and emergency vehicles cannot travel on or over the muddy areas, if necessary.

- 15 In dry, desert like climates, sand adjacent to runways and taxiways also creates problems. Little grows in sand, which leaves the airport with the unenviable choice of either planting, irrigating and maintaining an expansive and expensive natural grass surface or exposing large areas of aesthetically displeasing sand. Conventional
- 20 vehicles such as sanitation trucks, maintenance trucks and emergency vehicles also cannot travel on or over the areas having sand, if necessary. Windblown sand can also be a dangerous FOD, which in certain instances has been known to sand blast the inside of a jet's turbine engine.

As mentioned above, both wet and dry climates in combination with natural grass adjacent to airport runways and taxiways create potential safety problems; namely, through the creation of FODS and by potentially limiting access to and from the runway or taxiway.

5 Natural grass is also expensive to upkeep. In peak periods, some airport operators must mow twice a week. Weeds, high grass, muddy areas and other obstructions collect litter and debris intermittently over the entire airport or airfield. For example, Los Angeles international Airport currently maintains full time employees whose primary

10 responsibility is to collect litter and trash from the runways and taxiways and adjacent safety areas.

Although airfields are noisy and frequented by large, fast moving jet-powered aircraft, they still tend to support wildlife. Airfields often cover large expanses of open natural grass field surrounded by fences,

15 providing good visibility and a haven for birds and other animals from man and pets. Man-made retention basins and drainage ditches provide a convenient source of free standing water. Mowing machines leave behind mowed straw and the like for nest construction and shattered seeds and maimed insects for food.

20 Another well known and potentially dangerous safety problem furthered by natural grass are birds and other animals. Many birds including gulls, waterfowl, raptors such as hawks and other species flock to airfields to eat, drink and reproduce. Birds eat insects and grubs which live in natural grass up to six inches (15 cm) below the soil surface. Birds also eat rodents, which feed on the insects. Standing

water, especially after fresh rains, attracts many species of birds, including waterfowl. Large birds such as ducks or geese also create especially dangerous conditions for aircraft and are classified as FODs. Natural grass further provides materials and cover for birds to nest and

5 breed.

Many airports and airfields report collisions between airplanes and birds and other animals that have the potential to damage an airplane. In July 1998, a Boeing 757 struck a hawk while ascending from Dallas Fort Worth airport. The plane ingested the bird into its left

10 engine, tower personnel reported flames coming out of the engine and the plane landed safely. In May 1998, a Boeing 767 struck two Canadian Snow Geese while departing John F. Kennedy International Airport. The plane landed immediately with a damaged No. 2 engine and a hole in the right flap. In the same month, a Boeing 727 struck 15 Canadian Snow Geese while ascending from Colorado Springs Metro Airport destroying one engine, cracking the plane's radome and causing \$1.4 million in damage to the plane. Also in the same month, an F-16 struck white pelicans near Ainsworth, NE, which penetrated a windscreen and caused the pilot to eject.

20 In April 1998, an MD-80 struck geese ascending from La Guardia airport in New York. The geese destroyed the plane's radome. The plane had airspeed problems and had to divert to and land at Newark airport. In the same month, a Boeing 737 struck a bird 25 while ascending from Dane County Wisconsin Regional airport, damaging an engine and causing a precautionary landing. In March

1998, a Boeing 727 struck a bird on takeoff causing major engine damage and a runway to be closed to remove engine fan blades. In the same month, a Merlin 4 struck a bird on approach to Denver International, the pilot took glass to the face but landed safely. In 5 February 1998, a Cessna Citation flew through a flock of gulls in Watsonville, CA, which damaged its fuselage windows, an engine and several wing panels.

In January of 1998, a bird struck a Boeing 737 while leaving Salt Lake City International and damaged the plane's No. 1 engine. In that 10 same month, snow geese forced the emergency landing of a Boeing 727, damaged an engine, tore the radome and pilot tube from the aircraft and damaged both leading edges of the airplane's wings. Also in that same month, a Cessna Citation hit a deer during rollout at Horse Shoe Bay Airport in Texas, puncturing a fuel tank and spilling 200 15 gallons of fuel. In September of 1995, a bird air strike caused the crash of an E-3 AWACS aircraft at Elmendorf AFB, Alaska. In June 1995, a Concorde on final approach to John F. Kennedy International airport struck several geese, which destroyed two engines.

The problems created by birds are exacerbated by the variety of 20 birds. Often times eliminating one target species welcomes the arrival of another. For example, allowing grass to grow longer to discourage waterfowl promotes the rodent population, which in turn promotes the population of rodent eating birds. Known Bird Aircraft Strike Hazard plans, known as "BASH" plans, are trade-off creating methods that 25 require constant adjustment. For example, airports can have a

problem with gulls during winter months and smaller flocking birds in the summer months. If an airport produces known bird distress calls in its BASH program, the airport may have to produce gull distress calls in the winter and, for example, blackbird distress calls in the summer.

5       Birds are not the only species hazardous to airplanes and airports or airfields. Deer, usually in excess of one hundred pounds, and usually active after dark, can cause substantial damage and create potentially dangerous situations for pilots. Planes have been known to hit coyotes, which are attracted to areas having a large rodent population. Woodchucks and prairie dogs gnaw through underground wiring. Beavers can dam drainage ditches and flood airfields. An abundance of worms or other grubs on a runway, especially after a heavy rain, can also create a dangerous situation for planes taking off and landing.

10      Known animal, pest and BASH programs are either expensive, time consuming or illegal and in most instances do not solve all of the problems. One known solution is to employ a propane cannon. As stated above, airfields are already noisy, so that birds and other wildlife become accustomed to loud noises. Propane cannons also require active management. Live ammunition in combination with propane cannons is more effective, but live ammunition may not be legal, requires active management and is inherently dangerous.

15      Pyrotechnics (i.e., industrial or agricultural fireworks including shellcrackers, bird bombs and screamer sirens) are relatively effective and have been authorized for purchase by the United States Air Force.

Such techniques, however, require active management including proper placement. They are generally not audibly pleasing to humans and do not provide an acceptable solution for unknowing passengers taking off or landing in a commercial jet.

5        U.S. Patent No. 5,986,551, entitled "Method and System for Preservation Against Pesky Birds and Pest Animals", issued on November 16, 1999. The patent generally discloses a method and system for eliminating birds. The disclosure employs rotating-hunters and falcon imitators and requires sequentially, actively agitating the  
10      hunters or falcon imitators, removing all nests from an area that a system user desires to purge, and actively agitating the hunters or falcon imitators again. This is followed by a lessened, intermittent and protracted agitation.

Known hazing techniques such as loud noises and moving  
15      scarecrow type figures may provide a temporary solution. Hazing techniques at best only temporarily move birds and animals from one part of the airport to another, whereby the birds soon become habituated to the hazing and return. Each of the hazing systems requires active management, including proper placement and  
20      adjustment and has the drawback that whatever apparatus is in place to scare the birds or animals may also scare consumer airline passengers.

As described in detail below, the present invention includes replacing at least a portion of the natural grass surface adjacent to the  
25      runway and taxiways of an airport with a synthetic turf surface and an

accompanying sub-surface. The present invention includes a preferred turf specifically designed for an airport application. It is therefore desirable to provide background information on known synthetic turfs.

U.S. Patent No. 4,337,283 entitled "Synthetic Turf Playing Surface With Resilient Top-Dressing", issued on June 29, 1982 and discloses a playing surface for athletic games. The hallmark use for synthetic turf has been for sporting events particularly for sports such as football, rugby, soccer, golf, field hockey and baseball. These sports primarily make use of the synthetic turf's resiliency in the face of repeated severe shearing forces and of the turf's relatively low maintenance requirements. Synthetic turf also facilitates indoor stadiums and practice facilities that shield players and fans from harsh ambient conditions.

Referring now to Fig. 1, a front elevation sectional view through a known section of turf used for sporting applications is illustrated. The known artificial turf system 10 includes a base 12 that establishes the contour of the playing surface. The base 12 can consist of concrete or asphalt pavement, compacted clay, gravel rolled into ordinary dirt or any of a number of other firm materials. Although not shown, a slight slope or grade in the base 12 is preferable to facilitate surface water drainage.

Known sporting applications employing synthetic turf 14 can include a moisture barrier 16, such as a polyethylene sheet between 2 and 10 mils thick suitably adhered to the base 12. This reduces water penetration and protects the base from substantial ground moisture.

Sport applications typically employ a turf 14 that includes a tufted or knitted pile fabric backing 18, such as woven polypropylene. Manufactures of the turf 14 then tuft a multi-filament or fibrillated yarn 20 made from, e.g., 3/8 inch (.93 cm) wide polypropylene ribbon 5 mils 5 thick, which is slit and twisted to form a plurality of thin filaments or synthetic grass blades 22, through the fabric backing. If the yarn 20 is fibrillated, the thin filaments 22 remain connected at certain points so that the yarn if stretched apart creates a honeycombed mesh. Known strands of yarn 20 can comprise from twenty to fifty or more individual 10 filaments 22.

To look like grass, the manufacturer typically dyes the polypropylene green. The manufacturer can stitch three to eight multi-filament yarns 18 per inch (2.5 cm) on conventional tufting or carpet machines, creating rows of tufts that are commonly 3/8 inch to 3/4 inch 15 (.93 to 1.87 cm) apart. The length of the yarn filaments 22 (i.e., grass blades) can vary but is typically between 1/2 inch to 2 inches (1.25 to 5 cm) high.

Manufacturers can coat the underside of the pile fabric backing 18 with a resinous coating 24 that secures the tufts in place. The 20 coating 24 increases the dimensional stability of the backing 18 as well as the moisture resistance of the backing 18. A preferred manner of coating the backing 18 is to contact the back of the pile fabric with a solution of vinyl polymer in a volatile, non-aqueous solvent and then subject the pile fabric to a heat treatment to evaporate the solvent and 25 cure the vinyl polymer coating. Manufacturers can use conventional

polyvinyl chloride, polyvinyl acetate or natural or synthetic rubber latex coatings. The resinous coating 24 is sometimes referred to as a secondary backing and can also be considered a moisture barrier. In sport applications, it may then be possible to omit the moisture barrier 5 16 if the pile fabric backing 18 is provided with a suitable resinous coating 24.

In sport applications, after laying and adhering the synthetic turf 14 to the base 12, turf designers typically infill or infuse a layer 26 of compacted material comprising a mixture of resilient particles and fine 10 sand between the synthetic grass blades. Turf designers have been known to use a variety of different resilient materials, such as: (i) granulated cork; (ii) rubber particles including natural rubber or synthetic rubber; (iii) beads of synthetic polymers such as vinyl chloride, vinyl ethers, vinyl acetate, acrylates and methacrylates, 15 polyvinylidene chloride, urethanes, polyamids and polyesters; (iv) synthetic polymer foam particles; (v) vinyl foams such as polyvinyl chloride foams, polyvinyl ether foams, foamed polystyrene, foamed polyurethanes and foamed polyesters; and (vi) foamed natural rubber.

Turf designers often utilize or mix two or more of the above 20 mentioned resilient materials and can also add plasticizers, antioxidants and antistatic agents. Turf designers also preferably add fine sand to the infill to fill the interstices between the resilient particles to thereby form a more densely compacted infill layer 26. In sport applications, the sand is generally smaller in size than 30 U.S. screen 25 mesh size and is preferably between about 40 and 200 U.S. screen

mesh size. Fine sand also feels less abrasive to players when they contact the turf 14.

In typical sport applications, the turf designer provides an infill layer 26 from about fifty percent of the height of the synthetic grass blades 22 to substantially even with the top of the synthetic blades. In sport applications, turf designers typically prefer a projection of a synthetic blade between 1/8 inch and 3/8 inch (.31 and .93 cm) above the infill layer. Turf designers maintain an infill layer 26 substantially to the top of the synthetic blades 22 to prevent a playing surface from having a noticeable grain. Normally, the synthetic grass blades 22 have a characteristic grain (i.e., a tendency to lay in a given direction related to the direction in which the material passed through the production machinery). The infill layer 26 counteracts this tendency and prevents the playing surface from having an easily noticeable grain.

A relatively high infill layer 26 that includes resilient materials also absorbs much of the shock of an object impacting the playing surface and improves the footing of a player running or walking across the surface, particularly when making cuts or sharp turns. The non-abrasive character of the infill and the controlled and diminished synthetic blade height projecting above the infill make a playing surface much less likely to produce rug burns or abrasions when players contact the surface.

## SUMMARY OF THE INVENTION

One aspect of the present invention involves an artificial turf system for areas, and primarily safety areas, adjacent to airport and airfield runways and taxiways. This system includes an aesthetically pleasing artificial turf that repels birds and other animals and an accompanying sub-surface, which enhances water drainage and facilitates the accessibility of airport vehicles to all parts of the runway or taxiway if necessary. The present invention preferably replaces existing natural grass as well as an application specific volume of soil or other material beneath the natural grass in target areas in and around airport runways and taxiways. The present invention also applies to new airport or airfield installations, wherein the invention employs an existing graded and/or compacted surface without additional excavation and/or compaction or natural grass replacement. The present invention uses an application specific form of known artificial turf, which includes plastic, such as polypropylene or polyethylene, or otherwise synthetic fibers slit or fibrillated to appear grass-like. One embodiment of the present invention employs an application specific artificial turf, which includes the artificial or synthetic fibers and stiff fibers or repelling fibers otherwise uncomfortable for certain species to contact, walk on or lay on.

Beneath the artificial or synthetic turf, the present invention includes a sub-surface having an animal and plant retarding base, such as rock, crushed rock or concrete. The rock is preferably compacted to eliminate as much air as possible from between the rocks, to create a hard and stable surface. The base is thus able to support the weight of

an aircraft or airplane. That is, the base at least supports the weight of small aircraft in small airfield applications and preferably supports the weight of any large aircraft or airplane in commercial or military airport applications. In this application, "aircraft" and "airplane" are used 5 interchangeably. Both terms include all aircraft and all airplanes.

By removing the top soil and natural grass and replacing them with compacted rock and artificial or synthetic turf, the present invention substantially limits the plant and animal life that can or desires to exist in the target areas. The present invention virtually 10 eliminates grubs or insects that live on the surface or below the surface to a depth of approximately six inches (15 cm). The lack of natural grass, grubs or insects virtually eliminates rodents and other small animals that live in the natural grass and eat the grubs and insects. The lack of natural grass, grubs, insects, rodents and other small 15 animals virtually eliminates all food sources for birds, which provide the greatest potential danger to aircraft. The present invention likewise eliminates virtually all food sources for other animals including deer, coyotes, etc.

The lack of natural grass, the ability to grow natural grass and 20 the need to mow natural grass, which creates clippings convenient for nesting purposes, eliminates the cover and materials necessary for birds and other animals to nest and/or reproduce. The lack of natural grass also reduces the amount of environmentally unfriendly herbicides or pesticides that airport or airfield operators have to apply.

The present invention further includes a plurality of water drainage mechanisms to produce a target area near airport and airfield runways or taxiways substantially free from standing water or wet areas. Specifically, the present invention provides a layer of infill, 5 which is primarily sand, between the synthetic fibers, that sufficiently absorbs water and provides a first line of defense against standing water. For heavy rains, the present invention enables water to drain through the artificial turf of the present invention into a sub-surface retention area. The system includes additionally grading the soil 10 surface, creating the positive drainage necessary to eliminate standing water. The sub-surface of the present invention includes water sheeting layers or mechanisms, such as a waterproof membrane, to enable water to drain across the top of the turf leading into pipes or larger drains.

15 Removing standing water eliminates muddy or dead areas that currently proliferate at airports, resulting in a uniform, year round surface. The lack of available water eliminates another attraction for birds and other animals. A substantially dry surface in combination with a stable, compacted base also enables any type of airport vehicle 20 to reach any part of the runway or taxiway at any time of the year, if necessary, subject only to extraneous conditions. The lack of mud around standing water reduces the likelihood of mud reaching the runway or taxiway and becoming a FOD.

The present invention further preferably includes installing the 25 artificial turf, so that the grass tips of the turf are substantially even with

or below the surface of the runway or taxiway, and so that grass clippings (from areas not employing the present invention), dust, dirt and debris can blow across the runway or taxiway unimpeded by undesirable obstructions as a result of grass growing above their  
5 surfaces. Such debris can blow all the way to an airport fence, unimpeded by weeds or mud, which facilitates easier and more cost effective waste removal. The transition or distance from the runway or taxiway surface to the top surface of the synthetic turf backing also enables a positive water drainage from the runway or taxiway to the  
10 turf.

The artificial turf of the present invention requires less maintenance, i.e., an occasional vacuuming of airborne soil and other materials that has collected on the turf of the present invention, which can lead to a limited germination of seeds. The turf may also require  
15 limited spraying of herbicides or pesticides if weeds begin to grow. The turf of the present invention preferably includes polypropylene fibers representing grass blades, a woven polypropylene backing into which the fibers are woven, a polyurethane backing and a pure sand infill. Each of these materials absorb hazardous material spills, such as jet  
20 fuel, and are readily replaceable without exposing large areas of bare dirt near a runway or taxiway. Each of these materials also retards and reduces a fire, such as that related to a fuel spill or other incident.

Another aspect of the present invention involves a system for areas near the ends of airport runways which includes an aesthetically  
25 pleasing artificial turf that covers and forms part of a soft ground

arrester bed for slowing the motion of a runaway aircraft. The arrester bed system includes all the drainage features, aesthetics, ease of maintenance and accessibility of the artificial turf system described above. The arrester bed system employs a deeper base than the 5 artificial turf system, and the base of the arrester bed system preferably includes rolled rather than crushed rock, to soften the shock of an impacting plane and to absorb its kinetic energy. The arrester bed system also includes a turf area extending from the end of the runway a sufficient distance, preferably, on the order of a thousand feet (300 10 m), while the artificial turf system provides substantial benefits at sufficient distances, on the order of one hundred to two hundred feet (30 to 60 m).

A further aspect of the present invention is to provide a turf that inhibits or repels loitering animals. As illustrated above, the present 15 invention eliminates the attractions for animals including birds to congregate on the artificial turf of the present invention, including eliminating food, water and cover and materials for reproduction. However, certain species, namely seagulls, tend to loiter in areas for no apparent reason. To counteract such loitering, the present 20 invention contemplates using artificial turf having stiff or repelling fibers among the polypropylene fibers, which are uncomfortable to touch, stand on or lay on. The present invention contemplates that the stiff or repelling fibers bother the web-footed seagull as well as animals having paws or hoofs.

It is therefore an advantage of the present invention to provide an artificial turf system for airports and airfields that retards birds and other animals and has a sub-surface that enhances water drainage and as well as the accessibility of airport vehicles.

5 Another advantage of the present invention is to provide an artificial turf system for airports and airfields that includes an artificial turf surface and a sub-surface that slows a moving aircraft.

A further advantage of the present invention is to provide an artificial turf adapted to retard or repel loitering animals.

10 Other objects, features and advantages of the invention will be apparent from the following detailed disclosure, taken in conjunction with the accompanying sheets of drawings, wherein like numerals refer to like parts, elements, components, steps and processes.

## 15 **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a front elevation sectional view through a known section of artificial turf used for sporting applications;

Fig. 2 is a fragmentary top plan view of an airport or airfield, illustrating sections of airport runways, taxiways and areas of adjacent 20 synthetic turf of the present invention;

Fig. 3 is a fragmentary cross-sectional view, taken along line III-III of Fig. 2, of one embodiment of the artificial turf system of the present invention illustrating an airport runway section adjacent to an artificial turf surface, which includes a sub-surface having one or more 25 weed barriers;

Fig. 4 is a top front perspective view of a preferred pinning device, which includes a plastic coated steel reinforced T shaped spike having a pointed end to enable penetration of a compacted base material;

5 Fig. 5 is a fragmentary front elevation sectional view taken through a preferred embodiment of the artificial turf of the present invention;

10 Fig. 6 is a fragmentary top-front perspective view taken through one embodiment of artificial or synthetic turf, wherein a portion of the grass-like fibers is cutaway to illustrate a plurality of rows of stitch holes;

15 Fig. 7 is a fragmentary cross-sectional view, taken along the line VII-VII of Fig. 2, of another embodiment of the artificial turf system illustrating an airport runway section adjacent to an artificial turf surface, which includes a sub-surface having a water proof membrane and a weed barrier;

20 Fig. 8 is a fragmentary cross-sectional view, taken along line VIII-VIII of Fig. 2, of one preferred embodiment of the present invention for interfacing the artificial turf and associated sub-surface of the present invention with a drain or other obstruction;

Fig. 9 is a fragmentary cross-sectional view, taken along line IX-IX of Fig. 2, of one preferred embodiment of the present invention for interfacing the artificial turf and associated sub-surface of the present invention with natural grass;

Fig. 10 is a fragmentary top plan sectional view of an airport or airfield, illustrating sections of airport runways, taxiways and areas of adjacent synthetic turf employing a soft ground arrester system of the present invention;

5        Fig. 11 is a fragmentary cross-sectional view, taken along line XI-XI of Fig. 10, of one embodiment of a soft ground arrester system illustrating an airport runway section adjacent to an artificial turf surface, which includes a sub-surface having a soft ground arrester bed;

10      Fig. 12 is a fragmentary front elevation sectional view taken through one embodiment of an artificial or synthetic turf having spaced-apart repelling fibers; and

15      Fig. 13 is a fragmentary top front perspective sectional view taken through one embodiment of an artificial or synthetic turf having spaced-apart repelling fibers.

## DETAILED DESCRIPTION OF THE INVENTION

### Artificial Turf System

Referring now to the drawings, and in particular to Fig. 2, an airport or airfield 30 employing the present invention has runways, including taxiways and areas of synthetic turf 32 adjacent thereto. The artificial turf areas 32 are installed adjacent to the runways or taxiways 34 or sections thereof. The present invention contemplates installing the artificial turf areas 32 adjacent to or substantially adjacent to all the runways or taxiways 34. It is possible that certain presently existing runways or taxiways contain obstacles, such as drains, etc., along their side surfaces that do not allow the turf to be uniformly applied directly along their edge or side surfaces. The turf of the present invention, however, is preferably installed adjacent to the runway or taxiway wherever possible.

The artificial turf areas 32 are preferably installed on both sides of a runway or taxiway 34 and their surrounding areas, as desired by the airport operator, builder or maintainer. The greater the artificial turf area 32, the greater the benefit, as described above. However, any substantial turf area 32 produces some benefit. The turf areas 32 are adaptable to be installed to match any shape or contour created by the runways or taxiways 34, airport fences 36, natural grass areas 38 or by any other roads, driveways, accessways, pathways, trees, bushes, buildings, terminals, garages, hangers (not illustrated), or any other structures associated with an airport or airfield. The turf areas 32

likewise are adaptable to accommodate any interior obstruction, such as runway lights 40, interior natural grass sections 38 or other uses (if desired by the airport operator), drains or drainage ways 42, access roads, buildings, garages, hangers (not illustrated), or any other structures associated with an airport or airfield. One preferred interface of the present invention between the turf areas 32 and the natural grass areas 38 is described below.

The present invention includes any turf area 32 having any distance perpendicular to a runway or taxiway 34. It is preferable to have the turf areas 32 perpendicularly extend at least 150 to 300 feet (45 to 90 m) (transversely from the runway or taxiway to ensure a proper bird strike reduction. Many airports contain parallel runways less than 300 feet (90 m) apart. In such cases, it is preferable that the turf areas 32 extend from runway to runway (including from runway to taxiway and from taxiway to taxiway). As illustrated, the present invention contemplates installing the turf areas 32 on both sides of the runways or taxiways 34 and one or more of the runway or taxiway ends. Again, to ensure proper bird strike reduction, the turf is preferably installed 150 to 300 feet (45 to 90 m) perpendicular to the end of the runway or taxiway 34.

Referring now to Fig. 3, a fragmentary cross-sectional view, taken along the section line III-III of Fig. 2, of one embodiment of the artificial turf system 50 is illustrated, which includes an airport runway or taxiway section 52 adjacent to the artificial turf 54 and an accompanying sub-surface having one or more weed barriers 56. To

install the system 50 of the present invention, an implementor preferably:

- (i) excavates, grades, scarifies and compacts an application specific amount, volume or depth of the soil 58 to create a desired soil surface 60 (for existing airports and in certain instances for
- 5 (ii) installs a weed barrier 56 onto the soil surface 60;
- (iii) glues and ramsets a composite stud or member 66 using a suitable non-toxic glue and ramset 68; (iv) installs and compacts to tested specification an application specific amount, volume or depth of base material 70, preferably 3/4 inch (1.87 cm) minus crushed rock with
- 10 binder; (v) installs a second weed barrier 56, and staples (or otherwise suitably attaches or connects) the weed barrier to the top of the composite stud or member 66; (vi) installs a preferred two inch (5 cm) artificial turf by stapling and gluing (or otherwise suitably attaching or connecting) the turf initially to the composite stud or member 66,
- 15 sewing separate adjacent and interior sections of turf together as necessary, pulling the sewed section(s) taught, and driving pinning devices 74 in a preferred grid pattern to secure the turf before applying infill; and (vii) applying an application specific infill (preferably non-uniform sand) to an application specific height (preferably one inch (2.5
- 20 cm) below tips of the turf's grass-like fibers).

More specifically, Fig. 3 illustrates an existing runway or taxiway section 52 imbedded in the existing soil 58. The thickness or depth of airport runways or taxiways varies in accordance with airport or airfield engineering specifications. Many existing runways or taxiways are

- 18 inches (45 cm) thick or deep. The soil 58 includes a soil top surface 60

that is preferably below a runway or taxiway top surface 62, and which or abuts a side wall 64 of the runway or taxiway 52. To aid in the description of the present invention, the term "runway" hereafter refers to a runway, a taxiway or any other road traveled by airplanes.

5       The present invention contemplates the distance between the runway top surface 62 and the soil top surface 60 at the runway side wall 64 being application specific, but in any application, at least an inch (2.5 cm). Certain applications require more excavation than others. For instance, if the system implementor finds that the soil 58 adjacent to the runway side wall 64 is pure sand, the application may require that the sand be excavated initially to twelve inches (30 cm) below the runway top surface 62 at the wall 64. It is conceivable that the application could require 18 to 24 inches (45 to 60 cm) of initial excavation. The application is limited preferably to the thickness or 10 depth of the runway 52. That is, the system implementor preferably does not dig below or beneath the runway 52.

15      Most applications require an initial excavation of approximately six to ten inches (15 to 25 cm) of soil at the side wall 64. In a new airport installation, the system implementor alternatively specifies the proper depth and grade, whereby the airport engineers grade the soil 20 surface 60 to the appropriate specifications. For cost reasons, it is not desirable to excavate any deeper than necessary. It should be appreciated from the advantages of the present invention described above, however, that the top of the synthetic turf 54, i.e., the tips of the 25 synthetic grass blades, be approximately even with or slightly below

the runway top surface 62 at the wall 64. Also, the present invention preferably includes a suitable base providing structural stability, water absorption and a life retarding environment. The present invention therefore prefers an average initial excavation of six inches (15 cm) of  
5 the soil 58 at the side wall 64 of the airport runway section 52.

Although not illustrated in Fig. 3, the soil top surface 60 is preferably graded such that the system 50 enables water to drain away from the runway. In Fig. 3, therefore, water drains from left to right and the soil surface 60 is graded so that the soil is higher near the side wall  
10 64. The grade as well as the depth of excavation is application specific. That is, a particular airport can have a drainage system in place whereby the grade beginning at the runway side wall 64 is much steeper than normal. In such a case, the present invention contemplates working with and preferably enhancing the initial  
15 engineering plan and accordingly keeping the original steep grade.

Assuming that the application does not have a drainage system in such proximity to the runway side wall 64, the system implementor preferably grades the soil top surface 60 at approximately two percent. That is, for every foot (30 cm) measured from left to right from the  
20 runway side wall 64, the surface level preferably drops 1/4 inch (.62 cm). If possible, the system 50 maintains a constant grade, so that a 150 foot (45 m) application is gradually excavated to approximately three additional feet (90 cm) of soil from the side wall 64 to the end, 150 feet (45 m) away.

Certain airports have been engineered to handle or properly drain a hundred year flood, which requires more or less drainage depending upon the geographic location of the airport. Certain airports have existing retention or detention ponds that may or may not be

5 functioning properly. It is therefore probable that at some distance from the runway, each application of the system 50 is going to include a grade that departs, slightly or radically, from the preferred two percent grade. It is conceivable that the system 50 grades certain areas of the airfield as much as 60% to 80%, or however much is the

10 most beneficial to the airport.

Additionally, the system 50 preferably includes a scarified and compacted soil surface 60. Most surface soil exists at approximately 88 percent compaction. That is, surface soil is comprised of approximately 12 percent air. The system implementor preferably compacts the soil 58 on its surface 60 to between 90 and 97 percent.

15 Before compacting, the present invention contemplates scarifying, i.e., breaking up or roughing up the soil, similar to a rototile. The system implementor preferably scarifies approximately four inches of the unexcavated topsoil 58. Scarification enables better compaction,

20 which aids in providing a firm base.

Suitable scarification equipment is commercially available and well known in the art. For instance, a four-ton double drum roller can be used to compact the soil 58. The system implementor alternatively uses a sheep's-foot compactor, which contains an additional device for

25 stirring up the soil as it compacts the soil.

The artificial turf system 50 preferably includes a weed barrier 56 on top of the soil 58. The system implementor preferably lays the weed barrier onto the compacted soil surface shortly before installing a base material 70, as described in detail below. The weed barrier is a

5 plastic or other fabric, that retards upward weed growth and allows a steady and unimpeded flow of water in the opposite direction, i.e., downward. The weed barrier includes being woven, thermally bonded or otherwise suitably formed. A preferred thickness is 4 mils.

One weed barrier contemplated by the present invention is a Polyspun

10 350 brand drainage/weed control fabric made by Landmaster Products of Engelwood, CO.

The weed barrier 56 prevents weeds or other plants as well as grubs or worms from traveling from the soil surface 60 through the remainder of the system 50. The weed barrier 56 also enables the

15 water to flow from the system 50 into the soil 58. The maximum rate of the water flow through the weed barrier 56 is preferably not less than the rate of water flow through the remainder of the system 50 including the synthetic turf 54. The rate of water through standard synthetic turf is 25 to 50 gallons per hour per square foot, which the weed barrier 56

20 of the present invention is capable of handling. The weed barrier product specified above is believed to handle 300 gallons per minute per square foot.

The weed barrier 56 also functions as a mat or cover that provides stability as the remainder of the system is installed. When the

25 soil 58 is compacted it is in an unnatural condition whereby wind,

machinery, workers, etc., can kick up the soil 58, adding air to it and lessening the level of compaction. The weed barrier 56 counteracts the tendency for the soil 58 to decompress by not allowing the soil surface 60 to be easily disrupted. Accordingly, a heavier or thicker 5 weed barrier 56, e.g., 1/8 inch, (.31 cm) is preferably used in certain installations to provide additional stability on unstable soil.

The artificial turf system 50 includes maintaining an elongated composite stud or attachment bracket or member 66 horizontally mounted or connected to the side wall 64 of the runway 52. The 10 composite stud or member 66 includes being of any suitable size and shape desired by the system implementor. One primary function of the composite stud or member 66 is to establish the depth of the base of the artificial turf 54 and to provide an anchor on which to initially attach the artificial turf 54. Therefore, the correct depth and levelness of the 15 installation of the composite stud or member 66 below the runway surface 62 is important.

For a six inch (15 cm) excavation, preferably a 2 by 4 inch (5 by 10 cm) composite stud or member 66 is installed with the four inch (10 cm) side abutting the side wall 64, leaving room for a desired two inch 20 (5 cm) synthetic turf fiber to be substantially parallel with the runway surface 62 at the side wall 64 as illustrated in Fig. 3. The composite stud or member 66 is preferably synthetic and most preferably a solid, rectangular, recycled plastic bar having low deterioration characteristics. It should, however, be appreciated that the stud or 25 member includes being made of other suitable materials, sizes, shapes

having varying methods of construction. The member or stud, for example, further includes a hollow or rectangular tube or a suitable three sided structured beam.

The artificial turf system 50 includes gluing the composite stud 5 or member 66 to the runway wall 64. Both the runway 52 and the composite stud or member 66 are porous, so that when a suitable non-toxic glue, such as a PL400 glue by 3M, sets up, the stud is permanently fixed. The glue permeates both the concrete of the runway and the recycled plastic stud or member 66. The present 10 invention contemplates intermittently driving a plurality of ramsets 68 or concrete nails through the composite stud or member 66 into the side wall 64 of the runway section 52, primarily to hold the stud in place until the glue sets up. Employing such ramsets will minimize or eliminate any damage to the runway. It should also be appreciated that a 15 vibration damping material (not illustrated) could be installed in conjunction with the stud, bracket or attachment member 66 to dampen the runway vibration caused by airplanes and other vehicles.

The artificial turf system 50 includes a base material 70 that characteristically or inherently retards plant and animal life, absorbs 20 water and enables water to drain through to the weed barrier 56 between the base material 70 and the soil surface 60 and provides a firm and stable foundation for the synthetic turf 54. The base material 70 includes any material having such characteristics including, but not limited to: rock, crushed rock, concrete, or any combination thereof.

The base material 70 also includes sand in combination with rock, crushed rock or concrete.

The base material 70 is preferably a state approved road base, for example, 3/4 inch (1.87 cm) minus road base, which is commonly used in the construction of roads. The system 50 preferably includes installing the road base approved by the state or other regulatory authority wherein the application exists. Each state has an approved road base material, such as 3/4 inch (1.87 cm) minus road base. Three quarter inch (1.87 cm) minus road base includes crushed rock and binder, wherein the largest rocks have an average diameter of 3/4 inch (1.87 cm). The binder material is smaller fragments of rock including sand sized rock pieces.

After the base material 70 is placed onto the weed barrier 56, it is preferably smoothed and compacted. The system 50 includes compacting the crushed rock base material 70 in a manner similar to compacting the soil surface 60. Those skilled in the art of soil excavation and road base installation commonly compact crushed rock or road base. For example, a four-ton double drum roller can be used to compact the base material 70. The system implementor alternatively or additionally uses a sheep's-foot compactor to compact the base material 70, which contains an additional device for stirring up the base material. Optimally, the system implementor wets down the crushed rock and binder with water while compacting the base material.

The artificial turf system 50 includes installing a crushed rock road base that is tested and found to be compacted to at least 90 percent (i.e., 10 percent air or less) and preferably from 95% to 97% or above. Upon compaction, the dust and smaller rocks of the road base

5 fill the interstices between the larger rocks, creating a very solid stable base that preferably approaches 100% compaction. In this manner, the base 70 is able to support the weight of an aircraft or airplane. That is, the base at least supports the weight of small aircraft in small airfield applications and preferably supports the weight of any large

10 aircraft or airplane in commercial or military airport applications.

The height  $h$  of the base material 70 is application specific and is preferably equal to the depth of the excavation along the runway wall 64 less the height of the artificial turf 54, wherein the fiber tips are substantially parallel with or slightly below the runway surface 62 at the

15 side wall 64. In an application involving a six inch (15 cm) excavation and two inch (5 cm) high turf 54, the height  $h$  of the base material 70 is thus four inches (10 cm).

Alternatively, if the system 50 employs pure sand or a 1/4 inch (.62 cm) minus crushed stone as a base material 70, in an application

20 having a very stable soil surface 60, the height  $h$  includes being as little as 1/2 inch (1.25 cm). Further alternatively, the height  $h$  includes being as deep as 2 feet (60 cm), wherein the system 50 provides for maximum stability and water absorption.

The system 50 includes a second weed barrier 56 installed on

25 top of the base material 70. The system implementor initially staples or

otherwise suitably attaches or connects the upper weed barrier 56 to the composite stud or member 66 with suitable fasteners such as one inch (2.5 cm) galvanized staples 72, so that the system implementor can pull the weed barrier taught before laying the turf 54. It should be  
5 appreciated that one skilled in the art can suitably fasten the weed barrier 56 to any surface of the composite stud or member 66. Preferably, the weed barrier is fastened to the top of the stud or member 66.

The artificial turf 54, which weighs approximately ten pounds per  
10 square foot with a dry infill layer, secures the upper weed barrier 56 onto the base material 70. The upper weed barrier 56 is preferably the same weed barrier that is installed on the soil surface 60 and has the same water flow though capability as does the lower weed barrier 56. The system 50 therefore provides flow through drainage.

15 The weed barriers could be different for cost saving purposes, where it is contemplated that a more expensive weed barrier is applied on the soil surface 60, wherein weeds are more likely to propagate. Moreover, the system 50 contemplates not providing an upper weed barrier 56 in certain applications. For example, in certain areas, such  
20 as North Dakota, the soil is relatively alkaline such that weeds do not tend to grow, and so that an upper weed barrier 56 is not necessary. The system 50 preferably includes a lower weed barrier 56, even in an alkaline soil application, as added protection and to take advantage of the weed barrier's stabilizing effect.

The system implementor employs the flow through system 50 in a geographical area that generally allows the system to dry out. That is, the system 50 absorbs substantial rain and remains stable throughout if the weather eventually allows the system to dry. If the  
5 soil 58 becomes saturated from continuous precipitation, the system 50 can become less stable. The system implementor, however, handles such applications by varying the height  $h$  and thus the absorption and stability of the system. As stated above, the system implementor can also grade the system 50 to employ an airport's existing water retention  
10 and detention systems and thereby lessen the drainage burden on the system. The flow through system 50 is therefore applicable to many applications of the present invention.

The artificial turf system 50 includes a layer of flexible synthetic or artificial turf 54 on top of the upper weed barrier 56 of the system 50.  
15 The system 50 includes any suitable commercially available turf including the turf disclosed in connection with Fig. 1. One preferred flexible turf embodiment is described below. As previously described, the height of the fibers or grass-like blades of the artificial turf 54 is preferably substantially even or slightly below or parallel to the runway  
20 surface 62 at the wall 64. The top surface of the artificial turf 54 created by the substantially uniform tips of the grass-like fibers thereafter slopes as the soil surface 60 slopes, due to the grade.

The artificial turf 54 is attached section by section, beginning preferably along the runway wall 64 and on top of the composite stud  
25 or member 66. It should be appreciated that one skilled in the art can

fasten the turf 54 to any surface of the composite stud or member 66.

Preferably, the turf 54 is fastened to the top of the stud or member 66.

The turf normally comes in twelve or fifteen foot (3.6 to 4.5 m) rolls.

Once a section of turf is cut, the system implementor preferably runs a

5 bead or other suitable amount of non-toxic glue along the top of the composite stud or member 66, where the turf 54 is to be installed.

After putting the turf onto the stud or member 66 having the bead of glue, the system implementor preferably staples the turf to the composite stud or member 66, e.g., using suitable fasteners, such as

10 one inch (2.5 cm) galvanized staples 72. The galvanized staples 72 primarily hold the turf in place while the glue sets up. Both the flexible backing of the turf 54 and the composite stud or member 66 are porous, so that when a suitable non-toxic glue, such as a PL400 glue by 3M, sets up, the turf is permanently affixed to the stud. A meshed  
15 weed barrier 56 between the stud or member 66 and the backing of the turf 54 enables the glue to flow through the meshes of the barrier and into the porous materials.

The system implementor lays a plurality of sections along the runway wall 64 and on top of the composite stud or member 66 in the  
20 above described manner and sews the sections together in a conventional manner, so that the turf becomes one continuous piece.

Installing interior sections of flexible synthetic turf 54 also includes sewing a turf section to a currently installed section in a convention manner. Once a sufficient area of turf is laid down, such as a  
25 50 square foot section, the system implementor preferably drives pinning

devices 74 into the system 50, at various points, to pin the synthetic turf 54 and the underlying weed barrier 56 to the base material 70.

Referring now to Fig. 4, a T shaped spike 120 or pinning device used for the present invention is illustrated. The top horizontal section 122 of the pinning device is preferably four inches (10 cm) long although the appropriate length will vary with the installation. The horizontal section 122 is preferably circular in cross-section is preferably 1/4 inch (.62 cm) in diameter although the shape and diameter may vary based on the installation. The vertical spike section 10 124 is preferably ten inches (25 cm) long although the appropriate length will vary with the installation. The vertical spike section 124 is also preferably circular in cross-section and is preferably 1/4 inch (.62 cm) in diameter although the shape and diameter may vary based on the installation. The pinning device and specifically the horizontal section 122 and the vertical spike section 124 are preferably of steel reinforced bar, which are welded, forged, fastened or otherwise suitably fixed so that one end of the vertical spike section 124 connects substantially to the middle of the horizontal section 122.

The spike 120 preferably includes a plastic coating, such as 20 polypropylene or polyethylene of approximately 4 mils thick to prevent moisture damage and to provide a suitable contacting surface with which to strike and drive the spike 120. A pointed end 126, which preferably includes the bottom 1/4 to 2 inches (.62 to 5 cm) of the spike section 124, is driven into the base material 70. The relatively thick 25 spike 120 and the pointed end 126 facilitate penetrating the compacted

base material 70 and preferably the compacted soil 58. The outer surface of the plastic coating of the pinning device is preferably non-smooth, bumpy or irregular (e.g. from a ribbed reinforced bar) to increase the frictional engagement with the base material 70 and soil 58, which prevents vibration from causing the displacement of the pinning device.

The system implementor spaces the pinning devices 74 apart as needed, e.g., in a 6 foot by 6 foot (1.8 m by 1.8 m) grid or in a 10 foot by 10 foot (3 m by 3 m) grid, etc., preferably evenly spacing the pins such that for a 10 foot (3 m) grid and a 15 foot (4.5 m) wide turf roll, the system implementor leaves 2 1/2 feet (75 cm) on either side of two pins spaced 10 feet (3 m) apart. The pinning devices 74 primarily hold the artificial turf 54 taught while the infill is installed and prevent the system implementor from having to tear up infilled turf to smooth out a buckle in the synthetic turf 54. The infill layer is preferably approximately 10 pounds per square foot.

Referring to Fig. 3, many airports such as Los Angeles International Airport and Chicago's Midway Airport have limited runways. The installation of the artificial turf system 50 adjacent to the runway walls 64 may have to take place at night, e.g., from 10:00 PM to 7:00 AM, when air traffic and particularly air passenger traffic is somewhat lighter. In these critical areas, e.g., from the runway to 50 feet (15 m) in any direction, the wind direction can dictate where the system implementors work at any given time. If the wind changes and

the planes have to take off in another direction, the airport can order the system implementors out of an area.

The implementor cannot leave exposed dirt, sand or other objects that can become FODs in the critical areas. The implementor

5 will complete or at least cover an area before stopping work in the critical areas. Therefore, it is important not to excavate too much dirt at one time in a critical area. Once the installation extends past the safety area of the runway, e.g., 300 feet (90 m), the implementor can work at any time of the day and lay the turf in the most efficient manner. In

10 each installation, the airport operator preferably schools the system implementor on the airport's regulations and procedures including taxiway incursions that provide access to the installation.

#### A Preferred Artificial Turf

15 Referring now to Fig. 5, an infill layer 82 is illustrated in the preferred embodiment of the flexible turf 80 of the present invention. The preferred turf 80 is preferably laid over a sheet 84. As discussed above in the flow-through embodiment of Fig. 3, the sheet 84 is preferably a weed barrier. In a sheeting embodiment described below,

20 the sheet 84 includes a waterproof membrane. In certain applications, there is no weed barrier or waterproof membrane, in which case the preferred turf lays upon the base material 70. The turf, e.g., a 12 or 15 foot (3.6 or 4.5 m) roll of the preferred flexible turf 80 includes a primary flexible backing 86 preferably of double woven polypropylene and a secondary flexible backing 88, which is preferably polyurethane. The

thickness of the primary flexible backing 86 is preferably provided by the manufacturer. The thickness of the secondary flexible backing 88 is preferably between 10 and 20 mils.

The preferred turf 80 includes a plurality of fibers 90, which are 5 stitched into the primary backing 86. The secondary backing 88, applied after stitching, covers some or all of the stitch depending on the thickness of the secondary backing 88. The preferred turf includes 19 stitches per every three inches (7.5 cm). The fibers 90 are preferably fibrillated (i.e., separate filaments which remain connected at certain 10 points so that the yarn if stretched apart creates a honeycombed mesh) to form separate grass-like fibers 92. The fibers 90 are preferably polypropylene, 7500 denier and 32 ounces per square yard. Polypropylene has superior melting point and wear ability versus other materials, is adapted to be sprayed with pesticides and herbicides, 15 does not degrade upon contact with toxic jet fuel and limits the spread of fire from a fuel spill due to its fire retardant characteristic.

The height of the grass-like fibers 92,  $k$ , above the bottom of the secondary backing 88 preferably is 1/2 inch to six inches (1.25 to 15 cm), and specifically 1 1/2 to 2 1/2 inches (3.75 to 6.25 cm) and most 20 preferably 2 inches (5 cm). As illustrated in Fig. 1, the individual fibrillated or slit filaments are twisted together near the stitched end and come apart at the top. The preferred turf 80 includes a twisted fiber. Alternatively, the manufacturer makes the fibers 90 flat, so that 25 the individual grass-like fibers 92 stack one on top of the other, as illustrated in Fig. 5. The preferred turf 80 includes either style.

It is contemplated that most airport operators will desire that the manufacturer die the preferred turf 80 green. The present invention contemplates alternatively dying the preferred turf 80, or a portion thereof, any color desired by an airport operator. For instance, certain 5 airport operators may desire a brightly colored turf or turf portion, so that incoming pilots can easily find a runway.

The infill layer 82 preferably is a material that characteristically or inherently retards plant and animal life, absorbs water and enables it to drain through to the primary backing 86 and the secondary backing 10 88 and provides a firm and stable foundation for the fibers 90. The infill layer 82 includes any material having these characteristics including, but not limited to: rock, sand, concrete, plastic, fiberglass, rubber, ceramic material, cork, or any combination or derivative thereof.

The infill layer 82 is preferably crushed rock or sand and most 15 preferably washed sand. In certain instances, e.g., in the rainy Northwest, the infill layer includes being 1/4 inch (.62 cm) minus crushed rock (i.e., 1/4 inch (.62 cm)) average diameter rock down to rock particles) to enhance drainage. Referring to the terminology used in connection with Fig. 1, the infill layer 82 includes resilient materials, 20 such as: (i) granulated cork; (ii) rubber particles including natural rubber or synthetic rubber; (iii) beads of synthetic polymers e.g., vinyl chloride, vinyl ethers, vinyl acetate, acrylates and methacrylates, polyvinylidene chloride, urethanes, polyamids and polyesters; (iv) synthetic polymer foam particles; (v) vinyl foams, e.g., polyvinyl 25 chloride foams, polyvinyl ether foams, foamed polystyrene, foamed

polyurethanes and foamed polyesters; and (vi) foamed natural rubber.

However, the airport application of the present invention does not require the spongy, cushioned impact properties associated with sports turf.

Moreover, since rubber (the preferred resilient material in

5 practice) is lighter than sand, it tends to float to the top of an infill layer.

The rubber on top of the layer can then become a FOD that is sucked through a jet engine, where it can melt over a sensor.

In sport applications, as disclosed above in connection with Fig. 1, the sand is preferably fine sand between about 40 and 200 U.S. 10 screen mesh size to feel less abrasive to players who contact the turf. The size of the sand in the infill 82 preferably includes bigger sand particles that vary between about 4 and about 70 U.S. screen mesh size. The present invention does not require the sand to be less abrasive and is preferably in a range of sizes, which facilitates better 15 compaction.

The preferred turf 80 includes a compacted infill layer 82 of variable sand particles. The implementor may use a four-ton double drum roller and make one or more passes over the preferred turf 80. The length  $l$ , which is the average distance between the tips of the 20 grass-like fibers 92 and a top surface 94 of the infill layer 82, is preferably 1/8 to 5 inches (.31 to 12.5 cm) given that the contemplated variable turf height of the grass-like fibers 92,  $k$ , above the primary backing 86 includes being 1/2 inch to six inches (1.25 to 15 cm). The runway (i.e., runway, taxiway or any other road traveled by an airplane) 25 application of the turf preferably projects an inch (2.5 cm) of the grass-

like fibers 92 above the infill surface 94, wherein the free ends of the fibers 92 shield the sand infill 82 from the weather and from any air flow created by a jet or prop engines. Thus, in an application wherein the grass-like fibers 92 are preferably two inches (5 cm) high, the infill layer 82 is preferably one inch (2.5 cm) high, leaving a distance 1 of preferably one inch (2.5 cm). In contrast, sport applications, as described in connection with Fig. 1, preferably fill the turf with as much shock absorbing resilient infill as possible.

Referring now to Fig. 6, a top-front perspective sectional view through one embodiment of artificial or synthetic turf is illustrated, wherein a plurality of the fibers 90 are cutaway to illustrate a plurality of rows 104 of stitch holes 106. As above, the turf section 100 preferably includes a primary backing 86 and a secondary backing 88. The rows 104 in this embodiment are alternatingly curved, forming a serpentine shape, to prevent any possible "corn-row" effect from parallel rows. It has been observed that straight rows of the preferred turf described above do not produce a corn-row effect. The present invention therefore includes a turf having alternatingly curved or straight rows.

The rows 104 of the turf section 100 are preferably spaced apart from between 1/4 to 2 inches (.62 to 5 cm), are specifically spaced 3/8 to 3/4 inches (.93 to 1.87 cm) apart and most preferably spaced 3/4 inches (1.87 cm) apart. Known stitching machines are set to stitch rows in multiples of 3/8 inch (.93 cm), so if a system implementor desires a wider row, a row of 1 1/8 or 1 1/2 inches (2.81 or 3.75 cm) is likely the most feasible.

## Alternative Preferred Artificial Turf System

Referring now to Fig. 7, an fragmentary cross-sectional view, taken along the section line VII-VII of Fig. 2, of one embodiment of an artificial turf system 110 illustrates an airport runway or taxiway section 52 adjacent to the artificial turf 54 and a sub-surface having a weed barrier 56 and a waterproof membrane 76. A system 110 implementor preferably:

- (i) excavates, grades, scarifies and compacts an application specific amount of the soil 58 to create a desired soil surface 60 (for existing airports and in certain instances for a new airport);
- (ii) installs a desired weed barrier 56 onto the soil surface 60;
- (iii) glues and ramsets a composite stud or member 66 using a suitable non-toxic glue and ramset 68;
- (iv) installs and compacts to tested specification an application specific amount of base material 70, preferably 3/4 inch (1.87 cm) road base or 3/4 inch (1.87 cm) minus crushed rock with binder;
- (v) installs a second sheet, which in this embodiment is a waterproof membrane 76, and the staples or suitably attaches the membrane to the top of the composite stud or member 66;
- (vi) installs a preferred two inch (5 cm) artificial turf by stapling and gluing the turf initially to the composite stud or member 66, sews separate adjacent and interior sections of turf together as necessary, pulls the sewed section taught, and drives pinning devices 74 in a preferred grid pattern to secure the turf before applying infill; and
- (vii) applies an application specific infill (preferably non-uniform sand) to an

application specific height (preferably one inch (2.5 cm) below the tips of the turf's grass-like fibers).

The waterproof membrane 76 includes any commercially available pond liner or water impermeable membrane, preferably 5 between 2 and 30 mils thick. One possible waterproof membrane 76 made by Little Giant Pump Co. is a 20 mil thick plastic, e.g., polypropelyne, sheet, which a system implementor can order in ten or fifteen foot (4.5 m) wide rolls or sheets. The system implementor lays one fifteen foot (4.5 m) width in target areas near runways or taxiways 10 or lays a large area having the weed barrier. The implementor preferably lays multiple passes of the membrane employing a shingle-like overlap in concert with the grade to ensure down hill flow. Six inches (15 cm) of overlap is sufficient.

As stated above, the system implementor employs the flow 15 through system 50 of Fig. 3 in most applications. Most applications, however, will have one or more areas, usually near drains, retention or detention ponds, wherein the system implementor employs the waterproof membrane 76 in lieu of the upper weed barrier 56. The sheeting system 110 of Fig. 7 moves water along the grade as 20 opposed to the vertical absorption and drainage of the flow through system 50.

In one example of a sheeting application, a particular airport may desire to have an area of fifteen feet (4.5 m) adjacent to a runway or taxiway that is never to have standing water under any weather 25 conditions, e.g., access under any conditions. The system

implementor installs the sheeting system 110 for the first fifteen feet (4.5 m) in one method by: (i) gluing the membrane 76 to the composite stud or member 66; (ii) stapling the membrane 76, along the glue bead, to the composite stud or member 66 using, e.g., 1 inch (2.5 cm) sod pins; (iii) pulling the membrane 76 taught; (iv) gluing the turf 54 to the membrane 76; and (v) stapling the turf 54, along the glue bead, to the composite stud or member 66 using, e.g., 1 inch (2.5 cm) sod pins. After fifteen feet (4.5 m), the system implementor then installs the flow though system 50, which includes dual weed barrier layers 56.

Referring now to Fig. 8, a fragmentary cross-sectional view, taken along line VIII-VIII of Fig. 2, of a drainage system 130 illustrates another waterproof membrane application for the present invention. As mentioned above with respect to Fig. 2, the present system accommodates and preferably enhances existing drains or drainage ways. The drainage system 130 includes a concrete drain 132 having a drainhole 134 that allows water to drain into a main pipe, retention or detention pond (not illustrated). The drainage system is built into the existing soil 58, which is likely graded to run water to the drain 132.

In many instances, the land will have heaved or risen around the drain, not allowing proper flow to the existing drain. The drainage system 130 includes excavating, scarifying, regrading and compacting the soil 58 around the drain 132, installing a weed barrier 56 as described above, laying and compacting an application specific amount and type of base material 70, and then applying the waterproof membrane 76 and the turf 54.

The drainage system 130 preferably includes a lip 136 of material (exaggerated here for illustration) of approximately 1/16 inch to 3/4 inch (.15 to 1.87 cm), wherein the waterproof membrane 76 and the turf 54 extend past the edge of the drain 132, which enhances and

5 enables the water to drain smoothly into the drainhole 134 of the drain 132. The membrane 76 is preferably glued to the surface of the porous concrete drain 132 using the non-toxic glue and method described above. The infill layer, which is preferably washed sand, compresses the artificial turf 54 onto the membrane 76. The drainage system 130

10 also includes suitable ramsets or other suitable fastening devices driven into the concrete drain 132 (not illustrated) to hold the membrane 76 and turf 54 in place until the glue sets up. The system implementor applies the waterproof membrane 76, which sheets the drainage water to the drainhole 134, for at least three to four feet (90 to

15 120 cm) and preferably to ten or fifteen feet (3 or 4.5 m) around the drain.

#### Turf / Natural Grass Interface Embodiment

Referring now to Fig. 9, a fragmentary cross-sectional view,

20 taken along line IX-IX of Fig. 2, of one preferred embodiment 140 for interfacing the synthetic turf 54 and the sub-surface of the present invention with natural grass 142 is illustrated. As mentioned above with respect to Fig. 2, the present system includes interfacing with existing natural grass, such that an airport selectively installs synthetic

25 turf in target areas and specifically in areas adjacent to runways or

taxis. The system 140 includes a convenient method for securely interfacing the turf 54 with existing grass, such that the interface survives severe winds.

The interface embodiment 140 includes digging a trench 144 into the existing soil 58 along a desired interface line of the airfield. The trench 144 is preferably sufficiently deep to secure a piece of vertical turf 146 that is folded over the base material 70 and backfilled with compacted soil 148. A one foot (30 cm) deep by four inch (10 cm) wide trench is generally sufficient. Well known trenchers can dig thousands of feet of this trench in an hour. The system implementor then plants natural grass sod 142 or seed, depending on the proximity of the interface to the runway or taxiway (sod too close to the runway can fly up and become a FOD, however, a turf/grass interface is preferably at least 150 feet (45 m) from the runway or taxiway).

15

#### Arrester Bed System

Referring now to Fig. 10, a top plan sectional view of an airport or airfield 150, including sections of airport runways, taxiways and areas 152 of adjacent synthetic turf employing a soft ground arrester system of the present invention is illustrated. The present invention preferably includes the artificial turf system 50 or 110 (Figs. 3 and 7 respectively) in areas 32 adjacent to or substantially adjacent to the runway or taxiway sides 154. The present invention preferably includes the arrester bed areas 152 having an arrester bed sub-surface adjacent to the runway or taxiway ends 156 wherever possible. Again,

it is conceivable that the runways or taxiways contain obstacles, such as drains, etc., along their sides 154 or ends 156 that do not allow the turf to be uniformly applied along their edges.

The arrester bed areas 152 include many of the aesthetic and

5 drainage features of the artificial turf systems 50 and 110. The arrester bed areas 152 are additionally adapted to slow the motion and absorb the kinetic motion of an aircraft that has traveled off of a runway or taxiway. Particular airport operators or administrators may desire that the arrester bed areas 152 be additionally installed along a portion of

10 one or more runway or taxiway sides 154 to protect a plane that exits the runway or taxiway along their sides. As illustrated, the present invention additionally includes the arrester bed areas 152 adjacent to a portion of the runway or taxiway sides 154.

The arrester bed areas 152 are installable on one or both

15 runway or taxiway ends 156, as desired by the airport. The arrester bed areas 152 are adaptable to be installed to match any shape or contour created by the turf areas 32, runway or taxiway sides 154 and ends 156, airport fences 36, natural grass areas 38 or by any other road, driveway, accessway, pathway, tree, bush, building, garage,

20 hanger (not illustrated), or any other structure associated with an airport. The arrester bed areas 152 likewise accommodate any interior obstruction, such as runway lights, interior natural grass sections, trees, bushes, drains or drainage ways, interior or access roads, buildings, garages, hangers (not illustrated), or any other structure

25 associated with an airport. The interface embodiment of Fig. 9 also

applies to an interface between the arrester bed areas 152 and the natural grass areas 38.

The arrester bed areas 152 include any area of turf having any distance perpendicular to a runway or taxiway side 154 or end 156.

- 5 Airport operators most likely install the arrester bed areas 152 around runways, however, they are installable around taxiways as well. For purposes of illustration, the term runway includes runways, taxiways or any road traveled by airplanes. It is recommended that an airport install an arrester bed area 152 on both runway ends 156
- 10 perpendicularly from between 200 to 1000 feet (60 to 300 m) to provide enough area to properly slow a runaway aircraft. Many airports contain parallel runways less than 300 feet (90 m) apart. If so, the airports include a large arrester bed area 152 at each runway end 156, as shown, or include a plurality of individual arrester bed areas 152.

- 15 Referring now to Fig. 11, a fragmentary cross-sectional view, taken along line XI-XI of Fig. 10, of one embodiment of a soft ground arrester bed system 160 employing a synthetic turf and a sub-surface having an arrester bed is illustrated. A system implementor installs the arrester bed system 160 using a different sequence or method than
- 20 those described above in connection with the artificial turf system 50 of Fig. 3 and the system 110 of Fig. 7. Namely, the system implementor:
  - (i) excavates, grades, scarifies and compacts an application specific amount of the soil 58 to create a desired soil surface 60 (for existing airports and in certain instances for a new airport); (ii) installs a drain
  - 25 pipe 166 and a surrounding layer of washed rock 168, wherein the pipe

166 preferably leads to an airfield's drainage system; (iii) installs an application specific amount of arrester base material 78 onto the compacted soil surface 60; (iv) installs a thick weed barrier and stabilizer 164 on top of the arrester base material 78; (v) glues and 5 ramsets a composite stud or member 66 via a suitable non-toxic glue and ramset 68; (vi) installs a second arrester base material 162 onto the heavy weed barrier 164; (vii) preferably installs a thin weed barrier 56 or alternatively a waterproof membrane 76 onto the second arrester base material 162, and staples the barrier or membrane to the top of 10 the composite stud or member 66; (viii) installs a preferred two inch (5 cm) artificial turf by stapling and gluing the turf initially to the composite stud or member 66, sewing separate adjacent and interior sections of turf together as necessary, pulling the sewed section taught, and driving pinning devices 74 in a preferred grid pattern to secure the turf 15 before applying infill, and (ix) applying an application specific infill (preferably non-uniform sand) to an application specific height (preferably one inch (2.5 cm) below the tips of the turf's grass-like fibers).

The primary differences between the arrester bed system 160 20 and the artificial turf systems 50 and 110 of Figs. 3 and 6, respectively, include the typical locations of the systems disclosed above in Fig. 10 and the base material 70 of the prior systems versus the arrester base materials 78 and 162. The arrester bed system 160 includes a base material 78 that characteristically retards plant and animal life, absorbs 25 water, enables water to drain through to the soil surface 60 and

provides a cushioned or slightly collapsible, energy absorbing characteristic to the sub-surface of the arrester bed system 160. The arrester base material 78 includes any material having these characteristics including, but not limited to: rolled rock, sand, rubber,

5 foamed rubber, plastic, cork, or any combination or derivative thereof.

The arrester base material 78 is preferably washed 3/8 inch (.93 cm) rolled rock, which is commonly referred to as pea gravel. The rock used for the arrester base material 78 is preferably uncrushed, is preferably not compacted and is likewise of roughly the same size, i.e.,

10 3/8 inch (.93 cm) average diameter. The same size rock creates a layer having interstices or openings that enable energy absorption and facilitate flow through drainage. The arrester bed system 160 is preferably a flow-through rather than a sheeting system.

The height  $h$  of the base material 78 is application specific but is preferably the depth of the excavation along the runway end or side wall 64 less the height of the fibers of the artificial turf 54, wherein the fiber tips are substantially parallel with the runway surface 62 and less the height of a layer of a second base material 162. One major difference between the arrester bed system 160 and the artificial turf

20 systems 50 and 110 of Figs. 3 and 7, respectively, is that the height  $h$  of the base material 78 varies, while the top surface of the artificial turf 54 remains substantially flat and substantially coplanar with the runway surface 62.

The arrester bed system 160 preferably gradually brings a runaway plane to a stop. An arrester system having a deeper height  $h$

absorbs more energy more quickly. If the height  $h$  of the base material 78 is initially too deep, a runaway plane may stop too fast and cause the plane's landing gear to collapse and the cargo and passengers of the plane to lurch forward. The height  $h$  therefore preferably deepens 5 as the arrester bed system 160 spans away from the end or the side wall 64.

The depth of the excavation for the arrester bed system 160 is typically deeper than the depth of the excavation for the artificial turf systems 50 and 110 of Figs. 3 and 7, respectively. The arrester bed 10 systems 160 include an initial excavation at the runway end or side wall 64 of between eight inches and three feet (20 and 90 cm). The initial excavation includes being deeper than the depth or thickness of a runway, in which case the system implementor takes sufficient steps to not damage the integrity of the soil beneath the runway.

15 As illustrated, the system implementor grades the soil surface 60. The severity of the grade depends primarily on the length or perpendicular distance that the arrester bed system 160 spans from the end or side wall. The excavation typically reaches a depth of between 20 inches and four feet (50 and 120 m) depending on the 20 arrester base material 78 and the type and weight of airplanes taking off and landing at the airport. If possible, the system implementor employs a conventional grade of one quarter inch (.62 cm) for every foot (30 cm) in a direction perpendicular to the runway, approximately a two percent drop, until a desired depth is reached. In shorter

applications, e.g., 200 to 400 feet (60 to 120 m), the grade may have to be steeper to reach the desired depth.

After grading the soil 58, the system implementor preferably compacts the soil surface 60 to between 90 and 95 percent. Before 5 compacting, the present invention contemplates scarifying approximately four inches of the unexcavated topsoil 58. Scarification enables better compaction, which aids in providing a firm base. A four-ton double drum roller or a sheep's-foot compactor can be used to compact the soil 58.

10       The arrester bed system 160 is preferably a flow through system, wherein water drains vertically to the compacted soil surface 60, down the soil's grade and into a drain pipe 166. The drain pipe 166 includes any synthetic or metal pipe or tube and is preferably a 4 inch (10 cm) NPT PVC pipe. The pipe 166 lays parallel with the wall 64 and 15 captures drain water through perforations approximately 1/8 wide inch by two inches (.31 by 5 cm) along in the pipe's wall. The perforations are preferably spaced so that the longer two inch (5 cm) length runs radially along the pipe. The perforations are spaced apart approximately one half inch (1.25 cm).

20       To keep the soil 58 and arrester base material from filling the drain pipe 166, the system implementor preferably surrounds the pipe with one to six inches (2.5 to 15 cm) of washed rock 168 of sufficient size so as not to pass through the perforations. The system implementor preferably digs a suitable trench using a known trench 25 digger, fills the trench partially with the washed rock 168, lays the pipe

166 and fills the remainder of the trench with the washed rock 168. The implementor then installs or pours the arrester base material 78 to have a substantially flat surface that is parallel to the runway surface 62.

5       The implementor installs a heavy weed barrier 164 onto the surface of the arrester base material 78. The heavy weed barrier is a thick weed barrier, preferably 1/8 inch (.31 cm), which is plastic or other fabric, woven, or thermally bonded or otherwise suitably formed. The heavy weed barrier and stabilizer 164 includes a Polyspun brand  
10 drainage/weed control fabric made by Landmaster Products of Engelwood, CO. As above, the heavy weed barrier 164 prevents weeds or other plants as well as grubs or worms from traveling from the soil surface 60 though the remainder of the arrester system 160. The heavy weed barrier 164 also enables the water to flow from the  
15 arrester system 160 into the soil 58. The weed barrier 164 is thicker to provide extra support to the system, which preferably includes uncompacted arrester base material 78.

         The system implementor installs the composite stud or member 66 using ramsets 68 and non-toxic glue as described above in  
20 connection with Fig. 3. The implementor installs a second arrester base material 162 onto the heavy weed barrier 164. The arrester base material 78 is preferably uncompacted and likewise less adept at keeping weeds and other contaminants from propagating out of the soil 58 and traveling through the arrester base material 78 and the  
25 remainder of the arrester system 160. The second arrester base

material 162 includes any material that substantially retards plant and animal life, that allows flow through drainage and is preferably washed sand of between about 4 and 70 U.S. screen mesh size. A layer of the second arrester base material 162 is preferably constant throughout

5 the area of the arrester system 160, is preferably between one and ten inches (2.5 and 25 cm) deep and is preferably four inches (10 cm) deep or approximately the same as the height of composite stud or member 66.

The implementor installs a weed barrier 56 onto the top of the

10 second arrester base material 162. The preferred weed barrier 56 and its preferred method of installation are discussed above in connection with Fig. 3. In certain areas of the arrester system 160, the implementor may desire to sheet water. The arrester system 160 thus includes a waterproof membrane 76, described above in connection

15 with Fig. 7, in the place of the weed barrier 56.

A preferred two inch (5 cm) artificial turf 54 is installed such that the fiber tips are substantially coplanar or slightly below the runway surface 62, as described above in connection with Fig. 3. A washed sand infill layer (not illustrated) having varying sized granules, such as

20 the infill 82 of Fig. 5, is installed, smoothed and compacted by making one or more passes with a four-ton double drum roller, as described above. The method of laying, sewing, stretching, and pinning the artificial turf 54 of the arrester system 160 is substantially the same as that disclosed in connection with the system 50 of Fig. 3.

## Artificial Turf for Repelling Birds or Other Animals

Referring now to Fig. 12, a front elevation sectional view through an embodiment 170 of artificial or synthetic turf is illustrated, wherein a plurality of the grass-like fibers 90 are replaced by stiff, spiny, barbed, 5 needle bearing or prickly fibers or any combination thereof which are referred to herein as repelling fibers 172, and which repel loitering animals. The repelling turf 170 is preferably laid over a sheet 84. As discussed above in the flow-through embodiment of Fig. 3, the sheet 84 is a weed barrier. In a sheeting embodiment discussed in Fig. 7, 10 the sheet 84 preferably includes a waterproof membrane. A 12 or 15 foot (3.6 or 4.5 m) roll of the repelling turf 170 preferably includes a primary flexible backing 86, e.g., of double woven polypropylene and a secondary flexible backing 88, e.g., which is preferably polyurethane. The backings are alternatively any known primary or secondary 15 backing, some of which are disclosed above in connection with Fig. 1. The thickness of the primary backing 86 is preferably provided by a manufacturer. The thickness of the secondary backing 88 is preferably between 10 and 20 mils.

The repelling turf 170 includes a plurality of flexible fibers 90 and 20 repelling fibers 172, which are stitched into the primary backing 86. The secondary backing 88, applied after stitching, covers some or all of the stitch depending on the thickness of the secondary backing 88. The repelling turf in one embodiment includes 19 stitches per every three inches (7.5 cm) or any number of stitches disclosed above in 25 connection with Fig. 1. The flexible fibers 90 are preferably fibrillated

(i.e., separate filaments remain connected at certain points so that the yarn if stretched apart creates a honeycombed mesh) to form separate grass-like fibers 92. The fibers 90 include being of any material disclosed above in connection with Fig. 1 and are preferably

5 polypropylene, 7500 denier and 32 ounces per square yard.

The repelling fibers 172 include metal wire, stiff or hard plastic fibers, metal wire with a plastic coating, fiberglass fibers, etc. The repelling fibers 172 preferably include one or more relatively stiff plastic, e.g., polypropylene, polyethylene, polyurethane, nylon, polyester, etc., woven or monofilament (non woven) fibers 174 of approximately 10,000 denier.

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The stiff plastic fibers 174 are preferably stitched into the primary backing 86 with the flexible fibers, so that the repelling fibers also preferably include grass-like fibers 92. Fig. 12 illustrates that the repelling turf 170 includes repelling fibers 172 that are preferably tufted and folded over to form a U shape. That is, one repelling fiber 172 is preferably stitched, via existing stitching machines, through the primary backing 86 to form the illustrated U shape having two stems 176, each having a stiff plastic fiber 174. A compressive, frictional force F applied to the repelling fiber 172 by the primary backing 86, due to the stitching process, holds the repelling fiber 172 in place. The secondary backing 88 also clamps the fiber 172 in place.

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Alternatively, the repelling turf 170 includes a single repelling fiber 172 (not illustrated), which is again preferably a stiff plastic, e.g., polypropylene, polyethylene, nylon, polyester woven or monofilament

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fiber 174 of approximately 10,000 denier, and which is not folded over, but includes an attached end. That is, the alternative fiber 172 includes only one stem 176. One method for attaching a single repelling fiber 172 (not illustrated) is to provide a ball, tab or thicker portion at the 5 attached end of the repelling fiber 172, which enables the single stem 176, but not the ball or tab, to pass through the primary backing 86. The compressive, frictional force F applied to the repelling fiber 172 by the primary backing 86, as well as a clamping force applied by the secondary backing 88, secure the ball, tab or thick portion between the 10 primary and secondary backings.

Both the preferred dual stem or U shaped fiber embodiment and the single stem embodiment preferably include a stiff plastic fiber 174, of approximately 10,000 denier, as illustrated by the fiber 178. Both the preferred dual or U shaped fiber embodiment and the single 15 repelling fiber embodiment also contemplate including a plurality of stiff plastic fibers 174, of approximately 10,000 denier, as illustrated by the fiber 180.

As with the flexible fibers 90, the manufacturer preferably dyes the repelling fibers 172 green to appear grass-like. The present 20 invention contemplates alternatively dying the repelling fibers 172 as well as the repelling turf 170, or any portion thereof, any color desired by an airport operator. For instance, certain airport operators may desire a brightly colored turf or turf portion, so that incoming pilots can easily find a runway.

The height of the grass-like fibers 92 and the tips of the repelling fibers 172, k, above the bottom of the secondary backing 88 includes being 1/2 inch to six inches (1.25 to 15 cm), preferably 1 1/2 to 2 1/2 inches (3.75 to 6.25 cm) and most preferably 2 inches (5 cm). As 5 illustrated in Fig. 1, the individual fibrillated or slit filaments are twisted together near the stitched end and come apart at the top. The present invention contemplates using such a twisted fiber. Alternatively, the manufacturer makes the repelling fibers 172, such that the individual stiff plastic fiber(s) 174 and grass-like fibers 92 stack one on top of the 10 other. The repelling turf 170 includes either style.

The repelling turf 170 preferably provides an uncomfortable (but not unsafe) environment for birds and animals. That is, the stiff plastic fibers 174 preferably annoy an animal's paw or a webbed foot of a loitering bird, such as a seagull, but do not injure the paw or foot in any 15 way. The repelling turf 170 preferably quickly teaches the target animals to stay away before the system inflicts even limited damage. The present invention thus contemplates including the repelling turf in any of the artificial turf systems 50 and 110 of Figs. 3 and 7 and the arrester system 160 of Fig. 11, wherein the repelling turf includes stiff, 20 spiny barbed, needle bearing or prickly fibers or any combination thereof.

The infill layer 82 of the repelling turf 170 is any a material that characteristically retards plant and animal life, absorbs water and enables it to drain through to the primary backing 86 and the secondary 25 backing 88 and provides a firm and stable foundation for the flexible

fibers 90 and the repelling fibers 172. The infill layer 82 includes any material having these characteristics including, but not limited to: rock, sand, concrete, plastic, fiberglass, rubber, ceramic material, cork, or any combination or derivative thereof.

5       The infill layer 82 is preferably crushed rock or sand and most preferably washed sand. In certain instances, e.g., in the rainy Northwest, the infill layer includes being 1/4 inch (.62 cm) minus crushed rock (i.e., 1/4 inch (.62 cm) average diameter rock down to rock particles) to enhance drainage. Referring to the terminology used  
10      in connection with Fig. 1, the infill layer 82 includes resilient materials, such as: (i) granulated cork; (ii) rubber particles including natural rubber or synthetic rubber; (iii) beads of synthetic polymers e.g., vinyl chloride, vinyl ethers, vinyl acetate, acrylates and methacrylates, polyvinylidene chloride, urethanes, polyamids and polyesters; and (iv)  
15      synthetic polymer foam particles; (v) vinyl foams, e.g., polyvinyl chloride foams, polyvinyl ether foams, foamed polystyrene, foamed polyurethanes and foamed polyesters; and (vi) foamed natural rubber.

          The size of the sand in the infill 82 preferably varies between about 4 and about 70 U.S. screen mesh size. The repelling turf 170  
20      does not require the sand to be less abrasive and prefers a range of sizes, which facilitates better compaction. The repelling turf 170 includes compacting the infill layer 82 of preferably variable sand particles using a four-ton double drum roller by making one or more passes over the repelling turf 170. The stiff plastic fibers 174 are

therefore of a material that does not crack, snap or permanently deform upon compaction.

The length  $l$ , which is the average distance of the tips of the grass-like fibers 92 and the tips of the repelling fibers 172 above a top 5 surface 94 of the infill layer 82, includes the range of 1/8 to 5 inches (.31 to 12.5 cm). The airfield application of the repelling turf 170 preferably projects an inch (2.5 cm) of the flexible fibers 92 and repelling fibers 172 above the infill surface 94, which shield the sand infill 82 from the weather and from any winds created when the plane 10 takes off or lands. In an application wherein the flexible fibers 92 and the repelling fibers 172 are preferably two inches (5 cm) high, the infill layer 82 is preferably one inch (2.5 cm) high and the distance  $l$  is preferably one inch (2.5 cm).

Referring now to Fig. 13, a top-front perspective sectional view 15 through one repelling turf embodiment is illustrated, wherein a plurality of the flexible fibers 90 are replaced by repelling fibers 172 that repel loitering animals. The repelling turf section 182 has a plurality of the flexible fibers 90 and repelling fibers 172 cut away to illustrate a plurality of rows 104 of stitch holes 106. As discussed above, the 20 repelling turf section 182 preferably includes a primary backing 86 and a secondary backing 88 and the above described methods of repelling fiber attachment. The rows 104 in this embodiment are alternatingly curved in a serpentine shape to prevent any possible "corn-row" effect from parallel rows. It is contemplated that straight rows of the repelling

turf section 182 do not produce a corn-row effect. The repelling turf section 182 therefore includes alternatingly curved or straight rows.

The rows 104 of the repelling turf section 182 include being spaced apart from between 1/4 to 2 inches (.62 to 5 cm), but are 5 preferably spaced apart 3/8 to 3/4 inch (.93 to 1.87 cm) and most preferably spaced apart 3/4 inch (1.87 cm). Known stitching machines are set to stitch rows in multiples of 3/8 inch (.93 cm), so if a system implementor desires a wider row, a row of 1 1/8 or 1 1/2 inches (2.81 or 3.75 cm) is likely the most feasible. The repelling turf section 182 10 includes repelling fibers 172 interspersed among the flexible fibers 90, which the present invention contemplates interspersing a plurality of ways.

In one embodiment, the repelling turf section 182 includes interspersing one or more adjacent repelling fibers 172 among one or 15 more flexible fibers 90 of a particular row 104. In a single row, the repelling turf section 182 includes one or more adjacent repelling fibers 172 after every flexible fiber 90, after every two adjacent flexible fibers 90, after every three adjacent flexible fibers 90, etc., or after any number of adjacent flexible fibers 90, the number being from one to 20 one hundred flexible fibers 90. In a single row, the repelling turf section 182 includes one or more adjacent repelling fibers 172 after every 1/4 inch (.62 cm) of flexible fibers 90, after every 1/4 inch to 1/2 inch (.62 to 1.25 cm) of flexible fibers 90, after every 1/2 inch to 3/4 inch (1.25 to 1.87 cm) of flexible fibers 90, etc., or after any 1/4 inch (.62 cm) range 25 of adjacent flexible fibers 90, the ranges existing from between 0 to 1/4

inch (0 to .62 cm) to between 15 3/4 inches to 16 inches (39.37 to 40 cm).

Alternatively, the repelling turf section 182 includes interspersing one or more rows 104 of repelling fibers 172 among one or more rows 5 104 of flexible fibers 90. The repelling turf section 182 includes one or more rows of adjacent repelling fibers 172 after every row of flexible fibers 90, after every two adjacent rows of flexible fibers 90, after every three adjacent rows flexible fibers 90, etc., or after any number of rows of adjacent flexible fibers 90, the number being from one to fifty rows of 10 flexible fibers 90. The one or more rows of adjacent repelling fibers 172 include each being entirely comprised of repelling fibers 172 or, alternatively, interspersing the repelling fibers 172 among the flexible fibers as described above. The present invention also includes one or more rows of adjacent repelling fibers 172 after every 1/4 inch (.62 cm) 15 of flexible fibers 90, after every 1/4 inch to 1/2 inch (.62 to 1.25 cm) of flexible fibers 90, after every 1/2 inch to 3/4 inch (1.25 to 1.87 cm) of flexible fibers 90, etc., or after any 1/4 inch (.62 cm) range of adjacent flexible fibers 90, the ranges existing from between 0 to 1/4 inch (0 to .62 cm) to between 15 3/4 inches to 16 inches (39.37 to 40 cm).

20 While the present invention is described in connection with what is presently considered to be the most practical and preferred embodiments, it should be appreciated that the invention is not limited to the disclosed embodiments, and is intended to cover various modifications and equivalent arrangements included within the spirit 25 and scope of the claims. Modifications and variations in the present

invention may be made without departing from the novel aspects of the invention as defined in the claims, and this application is limited only by the scope of the claims.